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Dr. Albert Günther, F.R.S.,

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MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN FORMATION.

SUPPLEMENT No. IV.

PAGES 1—15; PLATES I—III.

DINOSAURIA (IGUANODON).

BY

PROFESSOR OWEN, F.R.S., D.C.L.,
FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,
ETC. ETC.

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SUPPLEMENT (No. IV)

TO THE

MONOGRAPH

ON THE

IGUANODON.

BONES OF THE FOREARM AND PAW. Plates I, II, III.

THE additional elements towards a reconstruction of the Iguanodon, which form the subject of the present supplementary monograph, have been contributed by SAMUEL HUSBANDS BECKLES, Esq., F.R.S., F.G.S., and their acquisition is due to his persevering labour, liberal indifference to expense, and intelligence directing the quest, resulting in the successful exhumation of the parts in question. They were associated with the greater part of the skeleton, of which, besides the subjects of the present Monograph, Mr. Beckles secured a dentary element of the mandible, fifty vertebræ, a sternum, scapula, and coracoid, one humerus and fragments of the other, one femur, one tibia and parts of the other, a tarsal bone, the three metatarsals, and phalanges of one hind foot, and some bones of the other hind foot.

Mr. Beckles was led to this excavation by a slight indication of bone in a Wealden clay (Hastings Series), about two miles to the west of St. Leonard's-on-Sea, Sussex. The area worked up was 200 feet square, or 10 feet by 20 feet, and 4 feet deep. The bed was below high water, and could only be wrought at during one tide in the day. Nevertheless the work of exposure was conducted with such energy that it was completed in a week. "The bones were imperfectly mineralized, and could only be secured by plaster of Paris, of which I used about thirty bags, each bag containing seven pounds. As a rule I applied the plaster with my own hands; but as the weather was severe, the wind being high and cold, with occasional sleet and snow, I was compelled to leave the manipulation of more than one bone to my navvies, and consequently one femur was destroyed, one jaw, one humerus, and one tibia, nearly destroyed. Had I not made a digging expressly for these bones, the interesting specimens you have in hand could never have been obtained."[1]

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[1] Extract from a letter by Mr. Beckles to the author, of the 25th September, 1871.

The half or ramus of the lower jaw preserved is represented by the dentary element, containing many of the characteristic teeth of the great herbivorous reptile, and repeating the peculiar form of the fore part of the mandible which has been recognized in previously described and figured specimens of that bone.[1] Though dislocated, displaced, and somewhat scattered in the matrix, they impressed the discoverer with the conviction or certainty of their being parts of the skeleton of the same individual. A comparison of all the bones and fragments of bone submitted to me for determination give no indication of their having belonged to more than one animal, and all are referable to an individual of the same age and size.

The left radius and ulna are in the best state of preservation; the right radius and ulna are less entire; an os cuneiforme is recognizable in the carpal series, and there are metacarpals and a few phalanges of both right and left paws.

The radius is chiefly remarkable for its powerful spinous or spur-like appendage.

The antibrachial bones in the present collection confirm the ascription to 'radius' and 'ulna' of the two bones imbedded near the upper corner, opposite the right hand, of the great slab of the 'Maidstone Iguanodon;'[2] but Mr. Beckles' specimens having been worked out of the less intractable matrix—the Wealden clay—show the configuration and characters of the surface of the entire bone.

In the following description the surface or aspect of the bone corresponding with the olecranon and 'back' of the hand is termed 'anconal;' the opposite surface, or that answering to the 'palm' of the hand, is termed 'thenal;' the surface toward that side of the forearm where lies the radius is termed 'radial;' towards the opposite side 'ulnar.' 'Proximal' and 'distal' imply the ends of the bone respectively next to or furthest from the trunk of the animal.

ULNA. Plate I, 55.

The ulna is 1 foot 5½ inches in length;[3] 4 inches 8 lines across the radio-humeral articulation (at *a*, *b*, fig. 1); 3 inches 8 lines across the distal end; 2 inches 10 lines being the greatest diameter of the middle of the shaft.

The olecranon (*c*, fig. 1) extends 1 inch 9 lines above the humeral articular cavity (*d*, *d'*); it is obtuse, about 2 inches thick at the base, thence gradually contracting, to be continued into the ridge (*a*, fig. 1) extending along or forming the ulnar border of the bone, to beyond the middle of the shaft, which then becomes rounded, and finally broadens to near the distal expansion of the bone (*k*, *k'*, fig. 1).

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[1] More especially in the portion of the mandible of a young Iguanodon. Palæontographical Society's 'Monograph of the Fossil Reptiles of the Wealden Formations,' 4to, 1855, p. 20, Tab. XI, *e*, *s*.

[2] Ib., Tab. XXXIV, 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' 4to, 1851. "The radius and ulna lie with their proximal ends next the right hand upper corner, the latter being distinguished by its prominent olecranon, which is rounded as in the Great Monitor," p. 112.

[3] The length of the ulna in the Maidstone Iguanodon is estimated at 1 foot 6 inches. 'Monograph,' *ut supra*, p. 114.

The humeral articular surface (figs. 1 and 2, *d*, *d'*) is oblong, and extends from above obliquely downward and forward to the strong anterior ridge (*e*), which, adding to its width, is then continued down to form (at *e'*) part of the cavity for the radius. The humeral surface is concave lengthwise, and also, in less degree, transversely; but both ulnar and radial borders become convex in that direction, or are rounded off and thick. The sharpest or best defined border is that which divides the lower part of the humeral articular cavity (fig. 2, *d'*,*f*, 'greater sigmoid' of Anthropotomy) from that (*g*) presented to the radius ('lesser sigmoid cavity,' ib.).

The length of the humeral cavity is 4½ inches; the breadth across the middle 2½ inches: the surface (*d'*, *f*, *g*, fig. 2) for the head of the radius appears to be directly continued over the well-defined lower part of the border (*d*,*f*) of the preceding cavity, directly downward, or with its plane in the longitudinal axis of the bone. This 'lesser sigmoid cavity' is semi-elliptical in shape, about 2 inches 8 lines in longest diameter, 1 inch 3 lines in the opposite direction; the upper border is straight, the lower one curved. The exact extent in the direction transversely to the head of the ulna, or in the long axis of the semi-ellipse, has suffered by fracture of the antero-inferior end or angle of the combined humero-articular cavities.

About half an inch below the radial surface the ridge (*e'*, fig. 1), continued downward from the above broken angle, expands to a rough tuberosity, which was joined by syndesmosis to a similar rough tuberosity (*r*, fig. 3) at the lower part of the anterior articular ridge of the radius.

At the proximal end of the ulna a thick, rough, long tuberosity, or tuberous ridge (fig. 2, *h*, *h*), from the radial side of the humero-radial articulation, is most prominent where it bounds or defines the radial division of that joint; below which it contracts and slightly bends to its termination (*h'*). This projection augments the breadth of the back part of the ulna below the base of the olecranon. At this part the ulna is almost flat, and the surface is roughened by thick irregular ridges, which mostly affect a longitudinal direction.

The general form of the bone at its upper three fourths is three-sided. The hinder side, continued from the above flat, rough expanse, maintains its character of flatness, gradually contracting to its termination 4½ inches above the distal end, where the shaft begins to be rounded.

The ulnar surface of the olecranon is moderately convex, lengthwise and across, for 3½ inches, or to below the middle of the humeral cavity. Then the surface begins rapidly to expand, by the development of the ulnar boundary (*e*) of the articulation for the radius, gaining a breadth of 4½ inches. The ulnar surface is here (fig. 1, *i*) moderately concave, both lengthwise and across; half way down the bone the concavity is changed to a surface flattened lengthwise, and moderately convex transversely.

The third or radial side of the shaft of the ulna has been somewhat crushed in, but seems to have been rather convex transversely, and is less sharply defined than are the other two surfaces. The thick rounded border between it and the hinder surface gradually subsides at the lower fourth of the shaft, and both blend into the somewhat flattened rough surface opposite the articular one at the distal expansion of the bone.

The thick rounded border between the ulnar and radial sides of the shaft contracts about the lower fifth of the bone, inclines forward, and extends into the beginning of the rugous margin (*k*, *k*′, fig. 1), which defines, by a convex curve, the lower or distal end of the bone.

The non-articular surface of this expansion is smooth anteriorly, where the radial facet of the shaft terminates; but is roughened by oblong tuberosities posteriorly, where the hinder facet of the shaft is lost upon it.

The articular surface for the distal expansion of the radius is of a crescentic shape, with the anterior horn the longest. It is rough and irregular on the surface, indicative of the ligamentous nature of the union. The smooth ulnar surface of the shaft terminates in the hollow of the crescent. The anterior horn extends 4 inches 3 lines above the distal end of the bone; the posterior horn 2 inches 6 lines above the same end. The general breadth of the syndesmotic surface is about 2 inches, contracting at each end of the crescent.

The compact bony wall of the ulnar shaft is from 6 to 9 lines in thickness; the fine cancellous centre, of an oval form in transverse section (fig. 4), is 1 inch 3 lines by 10 lines in its diameters.

In general shape, in the better definition of the joints for the humerus and radius, and in the development of the olecranon, the ulna of the Iguanodon resembles that of the larger living *Lacertia* more than that of the *Crocodilia*. From the ulna of the Iguana and of the large Nilotic Monitor it differs in the greater relative strength and more trihedral figure, the shaft of the ulna being compressed and two-sided in the smaller recent Lizards. There is the same concavity at the proximal part of the ulnar surface of the bone; but it seems relatively deeper in the Monitor. The chief difference in the Iguanodon is the thick tuberous extension on the radial side of the radial articulation, from which is continued that border which divides and defines the posterior and radial surfaces of the shaft.

Radius. Plate I, 54.

The length of this bone is 16 inches;[1] the greatest diameter of the proximal end (fig. 3) is 4 inches; of the distal end, from the upper border of the spur-surface (fig. 1, *m*) to the ulnar end of the distal articulation (ib. *n*) is 7 inches, 6 lines; from the lower border of the spur-joint (*o*) to the same part (*n*) is 5½ inches.

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[1] This appears to be its length in the Maidstone Iguanodon, but one end is covered by a crushed vertebra.

The proximal surface or 'head' (fig. 1, *p*), for articulation with the humerus, is semi-elliptical. The long diameter gives the breadth above quoted; the short diameter, at the middle of the ellipse, is 2 inches 4 lines; the truncate border or chord of the semi-ellipse is toward the ulna. From the posterior two thirds of this border the articular surface for the ulna (fig. 3, *q*) extends down, 1¼ inch, at right angles with the proximal surface. It is flat and rough, semi-elliptic in shape.

The proximal surface is almost flat, feebly undulate, with a linear roughness for ligamentous union with the humerus; it is continued at its fore part upon the ridge-like prominence of the bone (fig. 3, *r*, *r'*), which bends toward the ulna as it descends, terminating 2¼ inches below the humeral surface; this rough extension of the articular surface is separated from the flatter ulnar surface by a deep, smooth pit (ib. *s*), big enough to receive the end of the thumb. Beneath this articular surface the radius contracts to a breadth of 2 inches 5 lines, and a thickness of 1 inch 3 lines; and this subcompressed form, flat or subconcave toward the ulna, convex on the opposite side, but irregularly so on both sides, continues two thirds down the length of the shaft; which, then, gains in thickness and breadth, but especially and rapidly in the latter dimension by the extension of the distal end beneath that of the ulna.

The distal surface for articulation with the ulna commences about 9 inches from the proximal end of the radius in a pointed form (fig. 1, *t*), which rapidly expands to a breadth of 2¼ inches. This part of the distal ulnar surface is parallel, lengthwise, with the non-articular surface of the shaft of the radius, is almost flat or slightly convex and rough, and might be regarded as representing a partial interosseous syndesmosis; it is continued, however, at its lower broadest part into a smoother concavity upon the proximal side (ib. *u*, *v*) of the distal extension of the radius, and this concavity receives part of the distal convexity of the ulna (ib. *k*, *k'*). The distal end of the radius is excavated by two concavities for the carpal bones; that (ib. *w*) for the hemispherical part of the scaphoid is the deepest, and measures about an inch and a half in both transverse and fore and aft diameters; the shallower concavity (ib. *x*) for the convex part of the cuneiforme is continued into a slightly convex surface, extending to the apex of the distal extension ulnad (*n*) of the radius.

On the shaft of the radius may be noticed a rough, slightly prominent tuberosity (*y*), about 15 lines by 12, at the hinder or anconal margin, commencing about 4 inches from the proximal end. The shaft is not quite straight; the anconal surface below the tuberosity gains in thickness, and is slightly concave lengthwise; the thenal surface is thinner, and slightly convex lengthwise.

The exceptional feature of this radius is an oblong, irregularly flattened, rough surface, as if caused by fracture, occupying the radial aspect of the distal expansion (*m*, *o*); consequently, opposite the surface above described for articulation with the ulna. To this surface was joined, if not anchylosed, the base of a bone, corresponding with that which has been figured as the "horn" of the Iguanodon (*z*)[1]; the surface on the radius, like the co-adapted one on the base of the 'horn,' is 4 inches in long diameter, and 2 inches 4 lines in short diameter.

The unsymmetrical character of this supposed 'horn' led me to infer that it was one of a pair of bones, which I conjectured to be 'phalangeal.'[2] The rough flattened base of the original specimen, on part of which the cellular osseous texture was exposed, I believed to be due to the articular surface "having been chiselled or scraped away."[3] I now know that it was a natural surface due to separation from a close syndesmotic and partially anchylosed union with the distal end of the radius, as in the left antibrachial bones figured in Pl. I, fig. 1.

In the right radius of the Iguanodon, which has afforded the subject of the present Monograph, this horn-like appendage is anchylosed, and stands out from the radial side of the distal end like a process of the bone (Pl. II, fig. 1).

The length of the detached radial spine in the left fore-limb is 6 inches; the apex is not quite entire; the thenal surface (Pl. I, fig. 1, *z*) is less convex across and more convex lengthwise than the anconal surface (Pl. II, fig. 1, *z*). This surface is strongly convex transversely, slightly concave lengthwise, and is smooth along its distal half; it is roughened by thick and strong longitudinal ridges at its proximal third, and these are less developed at the corresponding part of the thenal surface.

The vascular channels indicate, as in a claw-phalanx, the system of supply of horny matter sheathing the bone.

The formidable spine, supported by this bony core, projected inward or from the radial side of the radius, with its distal border at right angles with the long axis of the bone, the proximal border (*z*) passing more obliquely to the apex of the spine-core.

The right ulna shows an exostosis at the back part of the shaft, near the base of the olecranon. Such instances of disease in Mesozoic reptiles are rare.

There is a slight difference in the shape of the proximal end of the right radius, which, nevertheless, belonged to the same individual Iguanodon, as the left one above described: the humeral surface, or 'head,' is 3 inches 5 lines by 2 inches 9 lines; the principal ulnar surface is 2 inches 3 lines by 1 inch 6 lines. The narrower surface for the ulna, extending upon the ridge-like process, with the digital depression dividing it from the broader ulnar surface, show the same characters, as at *r*, *s*, figure 3, Pl. I.

Fracture of the shaft of the right radius (fig. 5) shows a compact bony wall, 6 to 7 lines in thickness, surrounding a finely cancellous central tract: the shaft is sub-trihedral, approaching the cylindrical form prior to the distal expansion.

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[1] Mantell, 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 78, pl. xx, fig. 8.

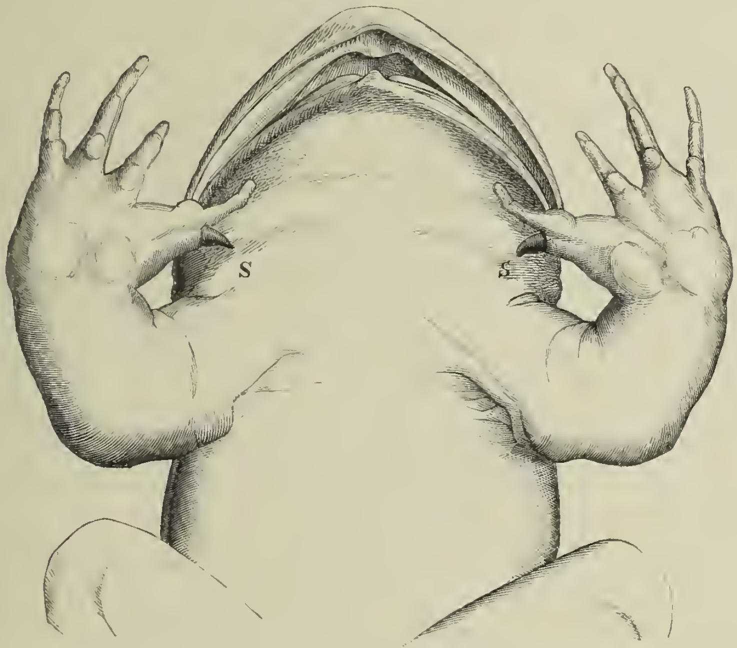
[2] 'Monograph on the Fossil Reptilia of the Wealden Formation,' 4to, 1855, p. 46.

[3] Ib., ib.

The radius of the Iguanodon resembles that of Lizards—*Iguana tuberculata, Monitor niloticus,* for example—in the larger and more definite extent of the proximal surface for the ulna, than exists in the *Crocodilia.* But no living reptile—crocodilian, chelonian, or lacertian—is armed like the extinct herbivorous Dinosaur.

Of other examples in the animal kingdom of limbs with spinous weapons, the first that suggested itself was the monotrematous reptile-like Mammals. But in both *Ornithorhynchus* and *Echidna* they are limited to the hind limbs, and are attached to the tarsus, not to the tibia.

Fig. 1.



Sexual spines of fore-limbs; or 'Hand-spurs,' Male of large S. Amer. Toad (*Cystignathus fuscus*).

In the class of Birds are a few 'spur-winged' species—*Anser gambensis, Parra jacana, Palamedea cornuta, Hoplopterus, e.g.*—in which the weapons are attached to the radial side of the fore-limbs; not, however, to the radius itself, but to the base of the metacarpus.

My friend and colleague, Dr. Günther, has kindly supplied me with the following example of spines or spur-like weapons in an existing cold-blooded air-breather; but it is a member of the Batrachian order. In *Cystignathus fuscus* a sharp, conical, horny spine, figure 1, *s, s,* is supported by a bony core attached to the radial side of the metacarpal of the innermost or radial digit.

Many species of Fish support and wield with effect formidable spinous weapons, forming part of the pectoral fins, the homologues of the fore-limbs in Iguanodon and other terrestrial Vertebrates.

The monotrematous and batrachian instances show the spinous limb-weapons to be related to sex, and to be present, or fully developed, only in the males.

In the class of Birds the carpal spurs are common to both sexes, but smaller in the female.[1]

The question remains—were the radial spines of Iguanodon common to both sexes, or developed only in one, most probably the male?

In the Maidstone specimen such appendage, with a concomitant considerable distal expansion of the radius, cannot be discerned. In the best preserved ends of the anti-brachial bones, those, viz., furthest from the humerus (as the separated fragments of the matrix, have been restored in the Maidstone specimen), the closest resemblance traceable to the more complete bones before me is at the proximal ends; and especially, as originally determined by me, in the ulna, or lower placed bone. In this view the distal ends, especially of the radius, are partly concealed by an overlying vertebra, yet not to the extent to obscure the beginning of the radial expansion if it had existed. The shafts of both radius and ulna seem to be more slender than in Mr. Beckles' Wealden specimen. It may be that this is of a male Iguanodon and the Maidstone specimen of a female one.

A strange instrument truly in aid of the amorous embrace; yet, as in the instance of *Cystignathus*, and perhaps also the *Ornithorhynchus* and *Echidna*, not without a parallel!

If the radial spines, on the other hand, were developed in both sexes of the Iguanodon, and wielded for purposes of defence by the otherwise weaponless herbivore, one cannot fail to discern in them a formidable means of transfixing an enemy—the carnivorous Megalosaur, *e. g.*—in a close death-struggle.

MANUS. Plate III.

With the right and left anti-brachial bones and spinous appendages several bones of both the fore feet were exhumed, but not enough for a complete restoration of either foot.

They give evidence that the fore-paw was pentadactyle, and that the terminal phalanges, at least of some of the toes, were short, obtuse, rough, serving for the support of horny matter in the shape of a hoof rather than of a claw. Such evidences of the carpal bones as were collected are more or less fragmentary; and, where a satisfactory union of those belonging to one and the same bone could be made, the homology of but one bone can be safely or with probability be suggested, that, viz., which answers to the large os cuneiforme in the carpus of Lizards.

The proximal surface of this bone is divided into a convex and concave surface; the former was apparently adapted to the concavity of the ulnar extension of the distal part of the radius; the concavity was adapted to part of the distal end of the ulna, but leaving the ulnar end of the distal convexity of that bone (Pl. I, fig. 1, *k*) for probable adaptation to an os pisiforme. The distal surface of the unciforme shows the concavity for an os magnum, and a well-defined flatter surface for a small unciforme.

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[1] The Secretary of the Zoological Society, P. L. SCLATER, Esq., F.R.S., kindly informs me that this is the case in the pair (male and female) of the spur-winged geese (*Plectropterus*) now living in the Society's Gardens.

The metacarpal of the pollex (Pl. III, I, *m*) is 4 inches in length; 2 inches 5 lines across the broadest part of the proximal end; 2 inches across the corresponding part of the distal articulation. Both these dimensions are in the direction of the transverse breadth of the paw, the bone being subdepressed. The proximal articulation is a shallow, circular cavity continued radially upon a rough, angular production of that end of the bone. The opposite side of the articulation is produced into a broader roughened surface for syndesmotic union with the base of the next metacarpal.

The anconal surface of the bone (shown in Pl. III), for an inch or more in advance of the distal end, is roughened by longitudinal grooves and ridges: the surface then continues smoothly to the distal convexity; but shows, on each side near that surface, evidence of the powerful lateral ligaments connecting this metacarpal with the first phalanx.

On the radial side is a rough oval pit, an inch in long diameter, with the proximal border prominent and forming an angle in the radial outline of the bone. There is a similar projection on the ulnar side, but it forms the proximal end of a triangular tuberosity.

The thenal surface of the bone is more or less rough, and is divided by a low medial prominence into two facets.

The distal articulation is of an oval shape, convex in a greater degree than the proximal articulation is concave; it is 2 inches across transversely, 1½ inch in the opposite direction, or from the anconal to the thenal surface. The plane of both proximal and distal articular surfaces is not quite transverse to the axis of the bone, but rather oblique from the ulnar forward to the radial end. The least transverse diameter, at the middle of the shaft of this metacarpal, is 1 inch 8 lines.

The metacarpal of the pollex of both right and left fore-feet has been obtained.

The first phalanx of the pollex (ib. I, 1) is broader and more depressed, in proportion to its length than is the metacarpal which supports it. Its proximal concavity is smaller and more shallow than the convexity to which it is adapted, though this appearance may be in some degree due to the abrasion of the margins. That part which is preserved equally bespeaks the strength of the ligamentous attachment with the metacarpal; it is most produced on the radial side of the bone (*a*), as if ossification had extended there along the lateral ligament toward the metacarpal. The opposite or ulnar roughened surface is broader, more tuberous, but less produced.

The anconal surface of the bone is less regularly convex transversely than in the metacarpal; the mid part being raised so as to divide it from the surface on each side, which is flatter transversely and slightly concave lengthwise.

The smooth surface on the radial side is continued along a notch at the radial border of the phalanx, upon the palmar surface of the shaft, two thirds across. All the rest of that surface is grooved and roughened for ligamentous attachment.

The distal end of this phalanx is 2 inches in breadth; of this, a feebly convex, semi-oval articular surface occupies a transverse extent of 1 inch 5 lines; the breadth from the anconal to the thenal border of this surface gives that of the distal end of the phalanx, viz. 1 inch.

The series of bones does not include any phalanx adapted to or agreeing in size with this surface. By the analogy of *Sauria* and *Crocodilia,* I conclude the missing phalanx would be the terminal one. Of the proximal phalanx of the 'pollex,' Mr. Beckles' series includes both right and left.

The second metacarpal (Pl. III, 2, *m*), or that of the index digit, is 6 inches in length. The proximal end is subquadrate, 2 inches in breadth, deviating from flatness by a slight convexity, most marked towards the ulnar side, where it probably projected into the cleft between the trapezoides and os magnum.

There is no indication of a smooth synovial surface; the union throughout, or nearly so, seems to have been ligamentous; the longest diameter in the ancono-thenal direction is toward the ulnar side of the surface, and is 1 inch 8 lines.

Near the radial side of the base is a rough surface of limited extent, apparently for ligamentous connection with the adapted surface of the first metacarpal.

On the ulnar side of the second metacarpal a rough flattened tract projects, like an exostosis, from the whole length of that side of the bone. Its ancono-thenal breadth at the base of the metacarpal is 1 inch 6 lines; it decreases to a breadth of 6 lines where it passes into the rough surface for the lateral ligament on the ulnar side of the distal end.

The anconal surface of the shaft is smooth, becoming roughened by linear striæ as it bends upon the radial surface. The thenal surface of the shaft is ridged and grooved throughout; it is nearly flat transversely, moderately concave lengthwise. The distal articular surface is moderately convex, 1 inch 4 lines in diameter; there is a protuberance on each side of the thenal part of the distal end; the ulnar side of the bone is slightly convex; the radial one in a greater degree concave; thus, the second metacarpal is slightly bent toward the radial side of the paw.

The bone described belongs to the left foot. The proximal part of the same phalanx of the right foot is preserved.

The proximal phalanx of the second toe (ib., II, 1) is 2 inches 6 lines in length; 2 inches in breadth at the proximal end; 1 inch 9 lines at the distal end. The proximal articular surface has the smooth synovial character but slightly indicated. It is subcircular in form, about an inch in diameter, with a very feeble concavity; the rough peripheral tract on nearly the same plane, from 4 to 6 lines in breadth, indicates how large a proportion of the joint had been syndesmotic: the protuberance for the lateral ligament on the radial side projects beyond the plane of the articulation; that on the ulnar side has a more distal relation to the joint. The anconal and lateral surfaces of the shaft form a continuous convexity transversely. The thenal surface is flattened, but irregular; an oblique groove extends from the radial end of the proximal surface for about an inch onward toward the ulnar side; this groove, 4 lines in breadth, seems to be natural; the clay matrix could easily be picked out of it. Beyond the groove the short thenal surface is moderately smooth and slightly concave; a pair of hemispherical tuberosities project near the distal articulation, and are continued into the tuberosities on each side of that surface. The form of the surface is trochlear, that is, concave transversely, convex ancono-thenally; feebly defined in both directions. The breadth is 1 inch 3 lines; in the opposite diameter 10 lines. The well-defined anconal border projects a little above the level of the corresponding surface of the shaft; the breadth of the shaft at its middle is 1 inch 3 lines.

To the well-defined smooth trochlear surface of the above phalanx is adapted a surface of corresponding size, shape, and smoothness at the proximal end of a phalanx, 1 inch 3 lines in length, 1 inch 4½ lines across that end (Pl. III, II, 2). The breadth of the distal articulation of this phalanx is 1 inch 2 lines; its ancono-thenal diameter is 6 lines, that of the proximal surface being 9 lines. Thus, the shape of this phalanx is subquadrate and subsphenoid; the apex of the wedge being cut off, so to speak, to form the distal joint. The upper surface of the short shaft is smooth, convex transversely, concave lengthwise. The under surface is flat, rough, and irregular, and is continued into rough prominences on each side of the shaft.

To the distal articular surface of the above phalanx is adapted the proximal one of the present (ib., II, 3, 3 *a*, 3 *b*), which is terminal, ending in a rough, obtuse, thickened border (3 *b*); the breadth exceeds the length in a greater degree in this than in the preceding phalanx; it equals 1 inch 3 lines, the length of the bone being 10 lines. The greatest ancono-thenal diameter of the proximal end is 9 lines, while that of the articular surface is but 6 lines; there is no trace of attachment for the claw. The non-articular surface of this obtusely wedge-shaped phalanx indicates by its roughness that it was imbedded in a callous sheath of the integument.

Thus we have evidence that the second digit of the fore-foot of the Iguanodon had three phalanges supported by a metacarpal; that it much exceeded in length the pollex or first digit, and that it was of less breadth, though with greater ancono-thenal thickness of the proximal phalanx.

The entire length of the four bones of the second digit is 10 inches 6 lines.

The metacarpal of the third or 'medius' (ib., III, *m*) digit is 6 inches 9 lines in length; the ancono-thenal exceeds the transverse diameter, except at the distal articulation, where the two are equal; the bone is most compressed laterally at the proximal end, which is strongly convex for being wedged or received into a groove-like cavity of the os magnum. The ancono-thenal diameter at this end of the bone is 2 inches; the transverse diameter at the anconal part is 1 inch 3 lines, but narrowing towards the thenal end. The radial side of the bone has a roughened tract, narrowing forward, and of the same extent as that on the contiguous surface of the second metacarpal; but it deviates from flatness at the parts, and in the degree in which that surface is convex in the attached bone. The two metacarpals were thus closely and ligamentously united, in a way and to an extent in which I have not observed the homologous bones in any recent Crocodilian or Lacertian. The anconal margin of the rough tract projects, ridge-like, along the proximal half of the bone. The anconal surface of the shaft begins, at an inch and a quarter from the proximal end, to be smooth, and is convex in both directions, but least so longitudinally. The ulnar surface of the shaft is roughened, but in a less degree than the radial one; the distal articular surface, single at its anconal half, where it is feebly concave, feebly concave transversely at its mid part, and much more convex in the opposite direction, has that curvature continued upon two lateral portions toward the thenal aspect of the bone, divided by an intervening channel.

The distal articular surface also inclines slightly to the radial side, where it projects beyond that surface of the shaft; it does not extend beyond the ulnar surface. It thus repeats the tendency to the bend radiad noticed in the second metacarpal, but here limited to the distal end.

The fourth metacarpal (Pl. III, IV, *m*) is 5 inches 6 lines in length; it is more compressed than the third, especially at the anconal part; the ulnar surface sloping anconad to meet the radial one, leaving the upper surface to be represented as a rounded border; thus, the shaft is trihedral, not quadrilateral. The proximal articular surface is 2 inches ancono-thenally by 1 inch 5 lines transversely. The chief part of the articular surface traverses that end of the bone in its long axis, with a strong convexity transversely, which passes into a flatter facet at the ulnar side; this ridge-like disposition of the chief articular prominence was probably wedged between the os magnum and unciforme. The ulnar flatter surface would articulate with the latter bone; in advance of this is a rougher tract, of small extent, for ligamentous articulation with a fifth metacarpal. The radial side of the fourth metacarpal is flattened and rough for junction ligamentously at its proximal part with the contiguous metacarpal; with an interval in the rest of the extent left by the concave curve, which this surface describes lengthwise, and which interval was probably filled up by looser ligamentous tissue.

The distal articulation, 1 inch 6 lines across, and the same in the opposite direction at the radial side, resembles in character that of the third metacarpal, but with an opposite obliquity tending to direct the toe which it supported more ulnad.

The corresponding metacarpal is preserved of the right fore-foot.

To either the third or the fourth digit belongs a proximal phalanx, 2 inches 6 lines in length, 1 inch 8 lines in transverse breadth of the proximal end, 1 inch 6 lines in the same breadth of the distal end, which supports a well-defined, smooth, shallow trochlear surface, 1 inch 1 line transversely by 10 lines ancono-thenally; it closely resembles the proximal phalanx of the second digit, but is rather narrower in proportion to its length, and shows greater disparity of size between the two distal tuberosities on the thenal surface. It may belong to the right paw.

A distal phalanx (ib., IV, 4), of the same character as that of the second toe, is longer in proportion to its breadth, and deeper ancono-thenally. The rough, obtuse termination is bounded below by a transverse groove indicative of an ungual callosity of a more definite form.

The fifth metacarpal of the right fore-foot (Pl. III, v, *m*, reversed) has been preserved. Its proximal surface is rather lozenge-shaped; the transverse diameter is 2 inches 3 lines; a circular, slightly concave, roughish articular surface is defined at the middle of the lozenge; the rougher tuberosities, extending beyond it on each side, form the truncate angles of the lozenge in that direction; a smaller extent of rough surface defines, in a feebler degree, the angles in the opposite direction. The length of this metacarpal is 1 inch 7 lines; the breadth of the distal end is 1 inch 8 lines. The upper surface is smooth, broad, and almost flat. The radial surface is continued into the thenal one, which is strongly concave lengthwise, and these combined surfaces are roughened by longitudinal ridges and grooves.

The ulnar surface slopes in that direction strongly from the upper one to meet the combined theno-radial surfaces; the distal articular surface is trapezoid in form, convex vertically, slightly concave transversely at its middle part, and continued upon a pair of tuberosities thenally; the toe which it supported would be directed obliquely to the ulnar side of the foot.

The skeleton of the fore-paw of the Iguanodon, carpus inclusive, may be set down as about 16 inches in length, and about 11 inches in extreme breadth, showing a like disproportion of size to the hind-foot which the humerus does to the femur.

In the Supplement,[1] No. 1, to the 'Monograph on the Fossil Reptilia of the Wealden and Purbeck Formations,' I remarked, in regard to its subject, "the resemblance to the hind-foot of the *Crocodilia* in the suppression of the fifth toe, and the resemblance of the third and fourth toes, in regard to their nearly equal length, to those toes in the Monitor, render it most probable that the tridactyle foot of the Iguanodon, here described, is a 'hind-foot;' but it cannot be assumed that the fore-foot may not have been similarly modified."

We have now the desired evidence, and know that the fore-foot was pentadactyle, and that its chief speciality is in the stunted character of the terminal phalanges, at least of the second and third digits. The entire length of the bony framework of the fore-foot, without the carpus, is 1 foot 1 inch; its breadth across the proximal ends of the metacarpals is 9 inches: the length of the bony framework of the hind-foot, without the tarsus, is 1 foot 8 inches; its breadth across the proximal ends of the metatarsals is 9 inches.

The fore-foot is smaller in proportion to the hind-foot in the Crocodile; it is still smaller in the Iguana.

The length of the bony framework of the hind-foot in a *Crocodilus biporcatus*, with a vertebral column, from the first cervical to the last sacral inclusive, of the length of 3 feet 2 inches, is 8 inches, including the tarsus; the length of the fore-foot, including the carpus, in the same skeleton, is 5 inches 4 lines.

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[1] Vol. of the Palæontographical Society, 4to, for 1858, p. 3.

In the skeleton of an *Iguana*, with the same part of the vertebral column 9 inches 3 lines in length, the length of the hind-foot, including the tarsus, is 4 inches 5 lines; that of the fore-foot, including the carpus, being 2 inches 3 lines.

In most recent *Reptilia* the fore limbs are shorter than the hind ones; in some of the tailless Batrachians the difference is extreme. But there is nothing in the proportions or structures, especially in the approach to the ungulate type of the unequal phalanges of the fore-foot of the Iguanodon, to justify, encourage, or even suggest that the fore limbs so terminated did not take their share, as in the Iguanas and Crocodiles, in terrestrial locomotion.

The notion of the Iguanodon being a biped, and walking like a bird, would, were it true, lend countenance to the reptilian hypothesis of the Ornithicnites.

But this notion would imply, not only ignorance of the structure of the fore limbs of the huge reptile, but also forgetfulness or disregard of the correlated conditions of avian bipedal progression on dry land.

In proportion to the bulk and weight of the bird, and to its limitation to terrestrial locomotion, is the extent of the trunk-vertebræ grasped by the splints or side bones ('ilia'), which transfer the weight of the body upon the hind limbs. Thus, the ostrich has twenty coalesced sacral vertebræ.

We have no evidence that the Iguanodon had more than four sacral vertebræ, and our knowledge of their characters is derived, as might be expected from the remains of a cold-blooded prone quadruped, from detached and unanchylosed sacral centrums.

Observation of the genesis of the bird's sacrum showed,[1] among other points, the alternating disposition of the central and neural elements; and progressive research into the osteology of the extinct *Reptilia* led to the recognition of a correspondence in this particular of the sacrum of the large Dinosaurs with that of Birds. But this afforded no ground to the Discoverer of the sacral structure for affirming or predicating a closer affinity of the Iguanodon or Megalosaur than of the Pterodactyle to the feathered class.

In the strong ligament of the head of the femur in Birds—in the depth of the socket for its reception—in the strength and close adjustment of the knee-joint, in which the fibula takes its share—in the well-turned trochlear form of the distal end of the tibia—in the rejection of any intermediate tarsus between it and the foot, and in the consolidation of the metatarsal bones for a firm and close articulation with the tibia, we may discern a perfect adaptation to the requirements of the single pair of limbs to which the functions of support, station, and progression on land, are exclusively confided.

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[1] Owen, 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27; Catalogue of the Osteological Series in the Museum of the Royal College of Surgeons,' 4to, 1853, p. 266.

The reverse of all these conditions is seen in the bones of the hind limbs of the Iguanodon and other Dinosaurian reptiles.

If one takes the pleasure of speculating on the genesis of *Didus* or *Dinornis*, guiding or reining the roaming fancy by facts, the geographical limitation of such ornithicnitoid species, and their primitive association exclusively with creatures of which they could have no dread, suggest the more obvious and intelligible hypothesis of derivation from antecedent birds of flight, whose wings they still show more or less aborted, according to Buffon's principle of transmutation by degeneration,—with a progressive predominance of the legs over the wings, ultimately resulting in a maximization of the terrestrial and abortion of the aerial instruments of locomotion.

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PLATE I.

Iguanodon Mantelli (nat. size).

Figs.

1. Left radius and ulna, thenal or palmar aspect.
2. Left ulna, proximal end, showing articular surface for the radius.
3. Left radius, proximal end, showing articular surface for the ulna.
4. Section of shaft of ulna.
5. Section of shaft of radius.

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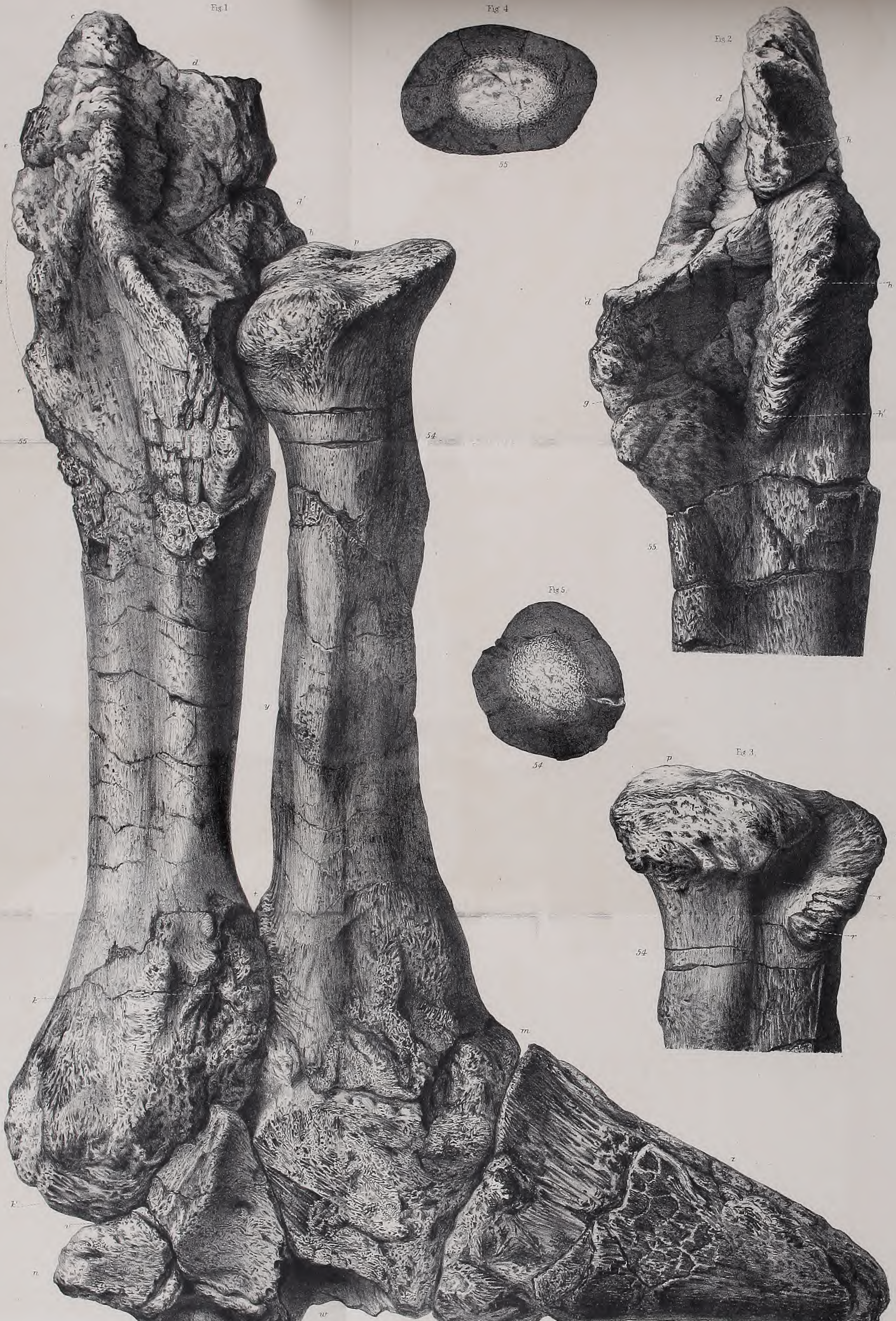

G.L. Griesbach del et lith.

IGUANODON MANTELLI ♂ (?)

Mintern Bros. imp.

PLATE II.

Iguanodon Mantelli (nat. size).

Figs.

1. Right radius, distal end, anconal or dorsal aspect.
2. Osseous core of radial spine, proximal or upper margin.

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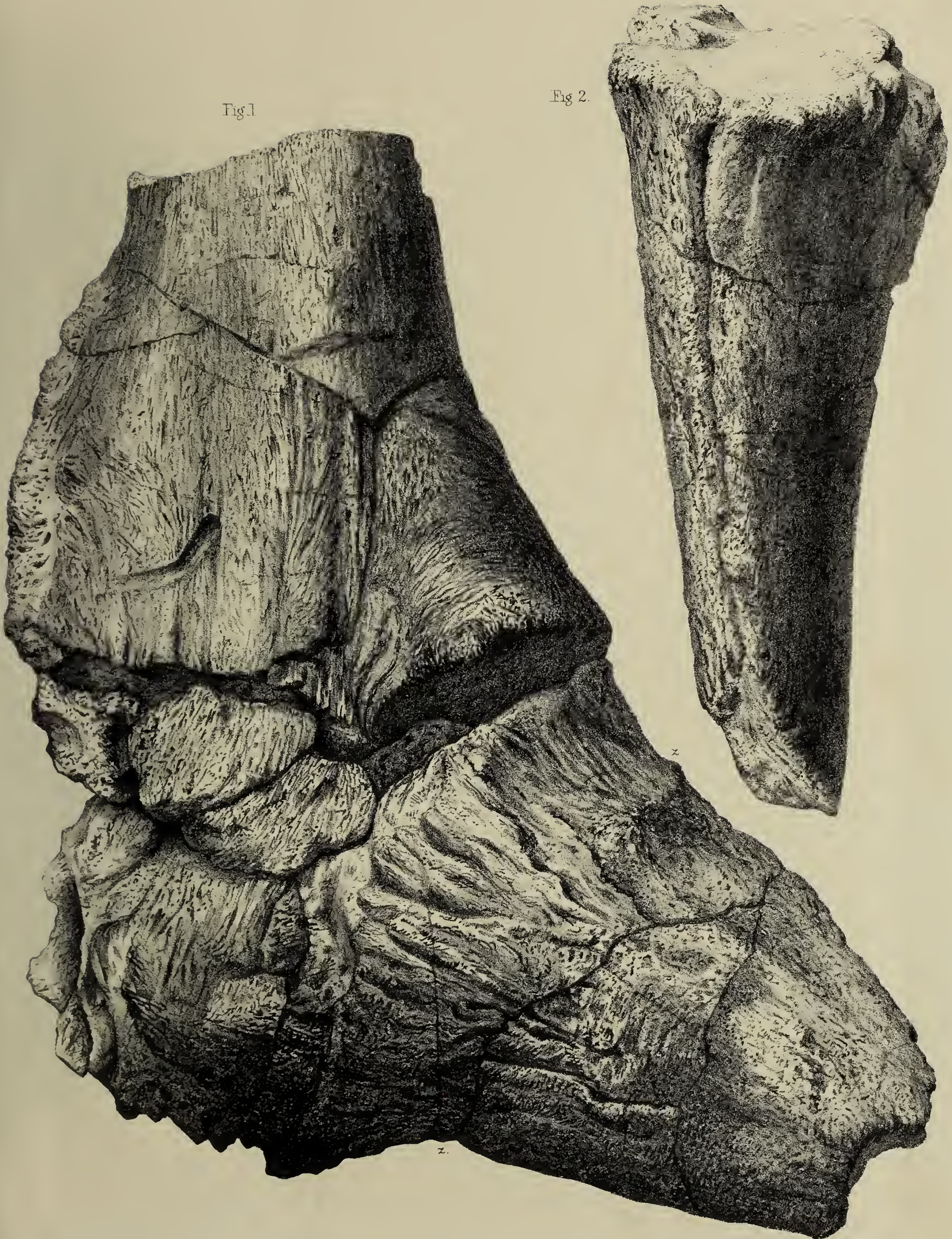
PL. II.



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IGUANODON MANTELLI

PLATE III.

Iguanodon Mantelli (nat. size).

Fig.

1. Bones of left fore-foot.

3 *a*. Ungual phalanx of second digit, proximal or articular surface.

3 *b*. Ib., ib., distal surface.

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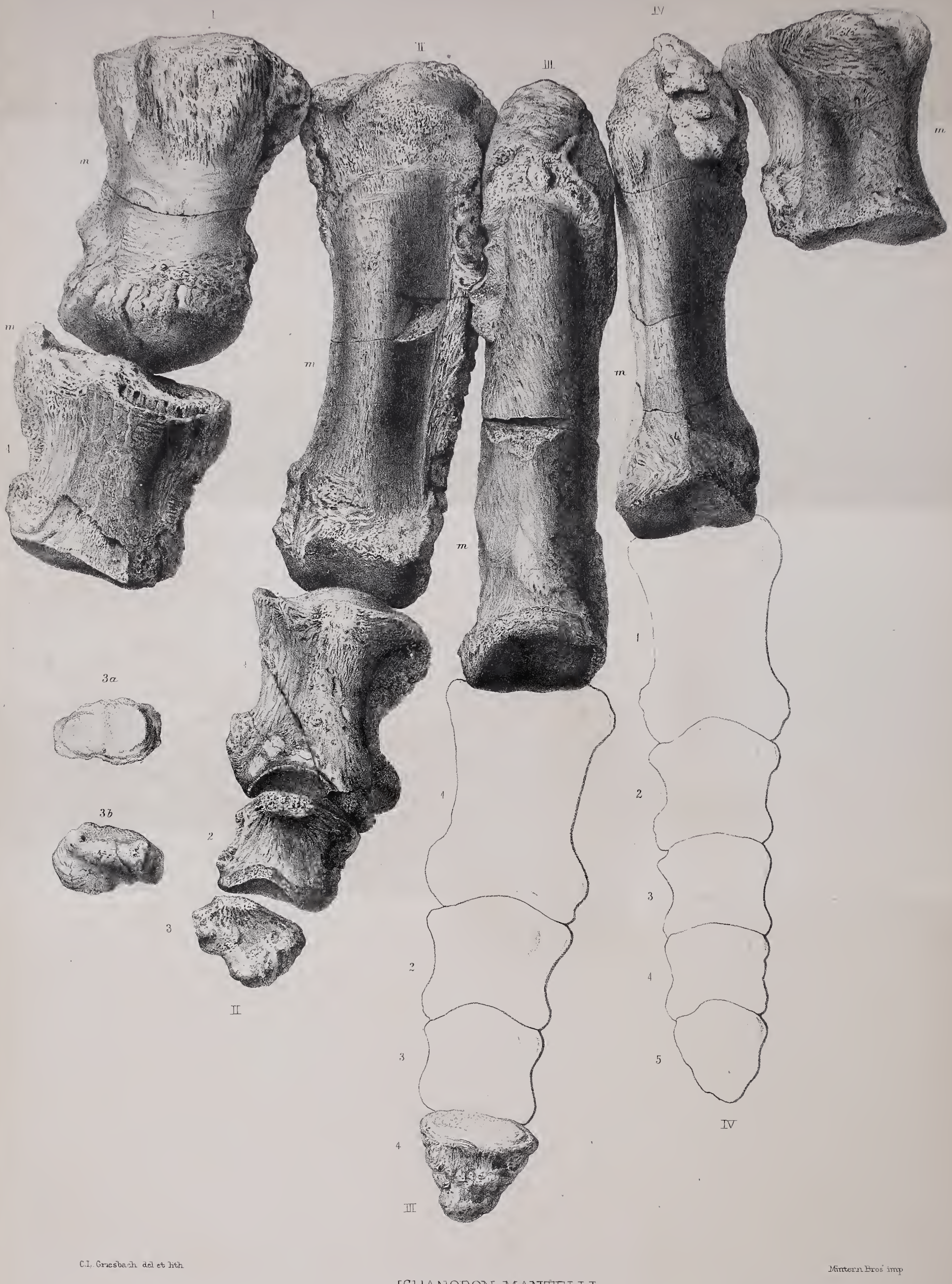
PL. III



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IGUANODON MANTELLI.